THE PROGRESSIVE FISH CULTURIST

NEWS AND VIEWS FROM MANY SOURCES ON PRACTICAL HATCHERY PROBLEMS

ISSUED BY THE
BUREAU OF FISHERIES, U. S. DEPARTMENT OF COMMERCE

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BUREAU OF FISHERIES U. S. DEPARTMENT OF COMMERCE

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OBSERVATIONS ON THE NUTRITION OF TROUT 1/

By C. M. McCay, Ph. D., Laboratory of Animal Nutrition,
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THE FOLLOWING observations on the food requirements of trout are the result of experiments carried on at the Connecticut State Hatchery at Burlington and later at the Cortland, N. Y., Experimental Hatchery of the U. S. Bureau of Fisheries by the author and his co-workers.

The hatchery at Cortland was put into service early in the summer of 1932. It was built purely as an experimental station to help improve the feeding methods used in the hatcheries of the country. The project represented cooperation on the part of the Conservation Department of New York State, the Federal Bureau of Fisheries, and Cornell University. The hatchery is fully equipped for carrying on experiments involving either a very few trout or thousands of them. Facilities for chemical balance studies as well as for growth studies are available.

THE COMPOSITION OF FEEDSTUFFS

Food materials, of course, vary greatly in their chemical composition. A valuable bulletin describing the chemical nature of American food materials is a publication by Atwater and Woods. (U. S. Dept. of Agric. Bull. No. 28.) Analyses from this are quoted today in most text books on nutrition. It is an excellent publication to consult when inquiring into the nature of any common foodstuff such as hatchery meats.

1/ A revision by Dr. McCay of the Memorandum I-130 (multigraphed) issued by the Bureau of Fisheries in 1935.

The following tables are based on values from bulletin No. 28:

The Chemical Composition of Some Fresh Meats Used in the Hatchery

	Water	Protein	Fat	Ash	Dry Matter	Calories per lb.
Beef:						
Heart	62.6	16	20.4	1	36.4	1160
Liver	69.8	21.6	5.4	1.4	30.2	665
Lung	79.7	16.1	3.2	1.0	20.3	435

The Chemical Composition of Meats on a Dry Basis

	Protein	Fat	Ash	Cals. per Gram	% Cals. as Protein
Beef:					
Heart	43.9	56	2.7	7.0	25
Spleen	75.6	18.8		4.9	63
Liver	71.5	17.9	4.6	4.8	59
Lung	79.3	15.8	4.9	4.7	67

Note: As it is a common hatchery practice to trim excess fat from hearts, the food as normally used probably contains considerable less fat than these tables indicate.

It is evident from the tables that hatchery trout normally receive much protein in the diet, averaging fifty percent or more of the total calories consumed. This is about THREE TIMES the requirements of any animal species that has been studied by nutrition experts.

THE PROTEIN NEEDED BY VARIOUS ANIMAL SPECIES

All animals need some protein in their diets. The amount of protein that needs to be included in the diet of an animal depends upon the quality of the protein. The protein found in such foods as gelatine, corn, eggs, flour, beans and meat is not all alike. Gelatine, alone, fed to dogs as a source of protein proved entirely worthless while meat was very satisfactory.

In determining experimentally the relative value of the proteins fed to animals different methods are available.

The amount of protein needed to cause a certain percentage increase in body weight affords one method of comparison. If it requires 15% of spleen as the only source of protein against only 10% of liver to give the same ratio of increase, then the liver could be given a better "quality" rating than spleen.

Another method consists in feeding the same amounts of different proteins at relatively low levels and comparing the percentage increase in the weights of the test animals.

A third, a reliable method, consists in measuring the NITROGEN in the feed, the amount of NITROGEN given off in the urine and feces, and, by difference, the NITROGEN stored in the body. The next table is based on experiments by Terroine who used this method with swine. (Bull. De la Soc. Scientifique d'Hygiene Alimentaire 31, 1933.)

Digestion of Proteins from Various Sources by Swine

Source	Percent digested	Percent retained
Whole milk proteins	96.5	67.6
Casein	98	50.4
Lean beef	94.7	49.5
Rye flour	88.3	38.4
Oats flour	91	39.9
Corn meal	94.0	33.5
Soybean flour	91.3	51.6
Bean meal	94.9	25.3

In 1915 Osborne and Mendel found that 12 to 15% of good quality protein was essential for growth in the young rat. (J. Biol. Chem. 20, 315.)

Trout grow much more slowly than such animals as rats, chickens, and swine. (See growth curves Trans. Am. Fish. Society 58, 205, 1928.) For this reason the protein requirements of trout should not exceed that of a rat and might be even lower.

Experiments to Determine the Protein Requirements of Trout.

Our first attempts to measure the level of protein required by trout were made in 1927 and 1930. (See Trans. Am. Fish. Soc. 57, 240, 1927 and Trans. Am. Fish. Soc. 60, 127, 1930.) By feeding synthetic diets made up of known elements it was found in both seasons' work that trout required between 11% and 25% protein in their rations. In these experiments casein from milk was the source of protein.

Taking advantage of these experiments a new series was completed in 1931. (Trans. Am. Fish. Soc. 61, 58, 1931.) In this case beef liver was employed to supply the protein. Beef liver was fed with a mixture of yeast, starch, mineral mixture and cod liver oil. The yeast added between one and two percent to the protein of the diet and this was taken into account. In this case liver was incorporated in the diet at a low level to furnish only 4% protein and at a high level of about 40% with several intermediate levels.

The results in the present case indicate clearly that 14 percent protein was the minimum level. This minimum level was reflected in the growth rate which was only slightly inferior to that found for diets richer in protein. The mortality rate gave excellent confirmation of the growth data. The mortality was heavy upon the diets containing 10% or less of protein while above this level the losses were insignificant.

During the past year new tests were run at the Cortland Hatchery for studying the conversion of nitrogen into body tissue by trout. These were run with fry varying the amount of liver in the diets in which liver furnished the sole source of protein. Much the same results were obtained as those above.

Conclusions.

Diets that exceed 15% protein are adequate for the growth of trout. For practical purposes the protein in a diet is easily estimated by the use of the tables of this number. Suppose beef spleen is being fed in the hatchery alone. From table 1 this diet contains 75.6% protein or 63% of the calories are in the form of protein. The trout in this case are being fed about four times as much protein as they require. Suppose a mixture of equal parts of cottonseed meal, dry skim milk and raw liver are being fed. The following approximation of the percent of protein calories in such a diet is satisfactory for use today in the hatchery. In a hundred pounds of such a mixture cottonseed meal would furnish 40/3 — 13 pounds of protein, dry skim milk would furnish 35/3 — 12 pounds of protein, fresh liver would contribute 20/3 — 7 pounds. Adding these contributions we find the diet contains about 32% protein on a wet basis. Since such a mixture has about 27% moisture, on a dry basis it would contain about 43% protein. In the above calculations the percent of protein in a given feed such as cottonseed meal was divided by 3 since it makes up a third of the ration.

If this same calculation is made to get crude protein as a percent of the calories instead of the dry mixture, the answer will be found to be 47%. These are only rough estimations but they are all that are justified at the present time since we know little concerning the percent of the different constituents that are digested by brook trout. This lack of information concerning digestibility is the greatest error. At any rate such calculations show trout are getting about three times as much protein as they require for growth and maintenance, in their feed. Two-thirds of all the protein fed is being burned for energy like starch.

Dry Skim Milk As a Practical Hatchery Feed.

If trout therefore use most of the expensive meat products for energy the thought naturally occurs whether or not there are other foods with a sufficiently high percentage of protein that can be used more economically in hatchery practice.

In table 2 we see that swine digested 96.5% of the whole milk proteins and retained 67.6% to build tissue. Is it possible to make use of milk products in the diet of trout?

Milk appeals to us as a food for young growing animals among those species that suckle their young. At first thought, however, it seems strange that milk should be a good feed for chickens and other birds. These species must have evolved without access to any food resembling milk, yet everybody has become accustomed to the term "milk fed chickens". It might be possible for the term "milk fed trout" to become equally familiar.

Dry skim milk is a standard feed which can be obtained through most any concern dealing with food for farm animals. It is made, of course, by drying milk from which the cream has been removed. An average dry skim milk has the following composition:

Water	3.9 percent
Protein	35.4 percent
Fat	1.7 percent
Lactose	48.7 percent
Ash	8.1 percent

These are terms that the chemist has been using for more than a hundred years. They are useful because they tell us at a glance that if we are feeding only dry skim milk to an animal that this animal is getting plenty of protein because most species need only about fifteen percent. It also tells us that there is plenty of mineral matter, because most animals need only four percent and this dry skim milk has more than eight percent of what the chemist calls ash. For most animals this diet is low in fat. Even herbivorous animals such as cows are usually fed 4 - 6 percent fat while every growing animal that is living on milk has a diet rich in fat. The milk of the horse is the lowest known, about 1%, while reindeer milk has 17% or about four times as much as ordinary milk that we drink. No one knows, however, whether fish require fat or not. From our experiments we believe they need very little, so dry skim milk should be satisfactory for a trout feed as far as its fat is concerned.

In our first experiments in 1927 we fed one group of trout only dry skim milk, another a mixture of dry skim milk and fresh beef liver, and still a third group a "synthetic" dry skim milk. This term "synthetic" as it is used by the biochemist has come to have a special meaning. It means that the chemist takes the substances

he has found by analysis and mixes them together, just as a cook makes a cake. To make synthetic dry skim milk we mixed together water, protein, fat, lactose, and ash in the percentages given for the composition of dry skim milk. This meaning of "synthetic diet" is extremely important and should be firmly fixed in mind. Upon this idea rests much of our nutrition practice today in feeding both men and animals. Most of our knowledge about vitamins has been gained through the preparation of synthetic diets. The outcome of the above experiments illustrates clearly the value of the method. In the first place those upon the milk-liver diet received nothing else for more than two years and made a normal growth. Those upon the skim milk alone grew well for three months and then failed. Those upon the synthetic milk grew only slightly and then failed.

Milk has been studied in the laboratories of the biochemist for more than a hundred years. Today we know far more than the student a hundred years ago but we can assert safely, that we know but a small fraction compared to that which remains to be discovered. Fifty years ago it was recognized that milk was very deficient in iron. In the late eighteen hundreds old von Bunge found that rats and mice were unable to make red blood cells if they were fed only rice and milk. Such young rats died of anemia. This lack of iron affords one explanation of the failure of animals to thrive upon milk alone. Even kittens will ultimately sicken and die if they are fed only milk. Later experiments showed that rats seemed to need also a trace of copper to make hemoglobin, the red pigment of the blood. Normal pure milk contains no copper.

These discoveries led us to believe that our failures with dry skim milk might have been due to deficiencies in traces of such metals as iron and copper. Therefore, we fed one group of trout upon dry buttermilk and another upon dry skim milk. To both of these feeds we added small amounts of zinc sulfate, copper sulfate, potassium iodine and ferric citrate. We also added 10 percent of a wheat germ extract and 5 percent of cod liver oil to be sure there was no failure because of vitamins. The trout all died in about the same length of time as those fed dry skim-milk or dry buttermilk with no supplements. These experiments told us that our failures with dry skim milk were not due to zinc, copper, iodine, nor iron. Furthermore, we learned that this deficiency of milk was not due to any of the recognized vitamins with the possible exception of C.

When milk, however, is fed with fresh meat, ESPECIALLY LIVER, the trout thrive.

Dry Skim Milk as a Food for Trout Fry.

Four years ago we made our first experiments in feeding fry from the very beginning upon a diet quite rich in dry skim milk. About ONE-THIRD dry skim milk powder and TWO-THIRDS raw liver with a little yeast and cod liver oil made up the diet. As soon as the fry were large enough they were weighed monthly until they had reached an average weight of an ounce. By this time the trough of fry on the milk diet was about 10% heavier than those receiving straight liver.

Subsequent experiments with fry, using a higher percentage of dry skim milk or dry whole milk with less liver, gave adequate growth but not so good as when the liver was incorporated at a higher level.

A ration consisting of one part cottonseed meal, one part white fishmeal, and TWO PARTS dry skim milk caused the fish to grow more slowly at first, and although the growth curve eventually returned to normal they never did make up for their retarded start. RAW LIVER was fed only once a week to this lot, so that it was concluded that it must be used more often during the earliest weeks of feeding.

Conclusions Regarding Dry Skim-Milk as Trout Food.

A large number of experiments, therefore, have convinced us that dry skim milk can be fed profitably in the hatchery. Excellent grades of dry skim milk are on the market today. The chief problem to overcome in using it as trout food is the matter of its physical composition. Dry milk is very soluble and unless some scheme is devised to bind it together most of the nourishment goes down the drain pipe.

A practical way to use dried milk is to grind it with the liver and allow the mixture to stand before feeding it to the fish. The juices of the meat tend to bind the milk into lumps.

One milk manufacturer has made some special granular forms of dry skim milk that dissolve very slowly in water. We are running a test upon this granular milk at the present time as it appears to be a real improvement.

Fish culturists can thus list dry skim milk among the best of the dry feeds available for trout. It can not be fed alone indefinitely, but we have found that with large fingerlings and older fish fresh meat feeding can be limited to once every two weeks. Small fingerlings appear to require fresh liver more often. Any fish culturist therefore who can devise a method to feed milk successfully is making use of a very excellent trout food.

COTTONSEED MEAL AS A TROUT FEED

The reader will have already observed that cottonseed meal has been a constituent of some of the test diets given in the section on protein and dry skim milk. More than two million tons of cottonseed meal are produced yearly in this country for use as cattle feed. A hundred years ago the product was virtually unknown. The popularity of cottonseed meal is because of its cheapness and high protein content. A typical analysis of this food is given in the following table:

	Prime Cotton-seed Meal	Meal used in our Experiments
Moisture	7.8	6.4
Fat	8.3	7.6
Ash	6.6	----
Crude Fiber	10.1	12.0
Crude Protein	39.8	42.9

At the present time the cottonseed meal in the northern market runs about 41% crude protein.

Its possibility as a fish food seems to have been overlooked in general for even the latest work dealing with the food of fish (Vol. III of Mangold's Handbuch der Ernahrung and des Stoffwechses, Berlin, 1931) makes no mention of it in an extensive list of dry goods tested in Germany on fresh water fish. If such a meal could be successfully employed as a trout feed the fish culturists would have an abundant supply of cheap food always obtainable. We have accordingly carried out many experiments testing the value of cottonseed meal as a food for trout.

In 1929-30 the diets of the following table were tested:

No.	Cotton-seed Meal	Dry Skim Milk	Fish Meal	Yeast	Cod Liver Oil	Cooked Starch	Dextrin	Alfalfa Meal
11	25	33	--	10	-	16	16	--
12	25	33	--	10	5	12	15	--
13*	33	33	34	--	-	--	--	--
15	33	34	34	--	-	--	18	15
16	33	--	34	--	-	--	23	5
17	33	--	34	5	5	--	23	--

* Best growth and lowest mortality.

Details of these trials were published in the Trans. Am. Fish. Society 60, 127 (1930).

In these diets no fresh meat was used and the brook trout failed in the course of about four months. The results, however, indicated that given a proper supplement a ration involving a considerable percentage of cottonseed meal would prove highly practical.

To secure additional data a new series of diets was planned.

No	Preserved Spleen	Fish Meal	Cottonseed Meal	Dry Skim Milk	Salt Mixt.	Cod Liver Oil	Alfalfa	Dextrin
21	30	—	25	—	3	2	—	40
22	25	25	20	25	—	—	5	—
23	25	—	45	25	—	—	5	—
24	—	25	45	25	—	—	5	—
25	—	—	70	25	—	—	5	—

The above rations were fed for a period of twenty weeks to brook trout with the following results:

There was NO MORTALITY in the trout on diets 21, 22, and 23 during the entire experiment.

Diet 22 gave the best growth.

Diet 24 gave a moderate growth and a high death rate.

Diet 25 gave a poor growth and a heavy mortality.

The cottonseed meal thus gave a good account of itself, not appearing to be toxic for trout even at the high level of 70%. This contrast with linseed meal has been found by several workers to be very toxic. (Trans. Am. Fish. Soc. 1929.) Even such an unusual material as preserved spleen as the meat supplement proved satisfactory in the best of the diets listed. Cottonseed meal has proved useful in a number of producing hatcheries where it has been employed.

Meats Used as Supplements for Cottonseed Meal Diets.

The preserved spleen just mentioned might be worth the attention of men whose hatcheries are located at places where fresh meat is difficult to obtain and keep in good condition. Preservation in alcohol makes it lose none of its value as trout food.

It was thought advisable to give other meats a thorough trial with cottonseed meal in order to find out if any one meat would prove more satisfactory to use. Trout were carried for 28 weeks on diets in which beef liver, kidney, lungs, heart or spleen made up the meat constituent. The dry element consisted of two parts cottonseed meal and one part dry skim milk. This dry mixture was fed 50-50 with the fresh meats listed. All lots of trout grew well with little loss. Beef liver was the best meat supplement with the others rating according to the above listing. (See Trans. Am. Fish. Soc. 61, 58, 1931.)

In another series of experiments ground sheep plucks made up the meat element. The dry constituent consisted of a mixture of cottonseed meal and dry skim milk in equal proportions. This dry food was combined with the meat as ONE THIRD of the total ration. Although skim milk from four different sources was employed, the fish all made a moderate but not an optimum growth. One lot also received dry buttermilk with results only slightly inferior to the skim milk. (See N. Y. State Con. Dept. 1933. Report of Cortland Hatchery.)

A third feeding trial made use of the same dry mixture mentioned in above paragraph, but it was fed 50-50 with three different fresh meats. After 24 weeks there was no significant difference.

The results of these experiments with cottonseed meal thus revealed that it could be successfully used in the diet of young growing trout, provided the fish received a certain percentage of fresh meat also.

Other Dry Meals Used as Supplements for Cottonseed Meal.

In 1928-29 a study was made of the comparative value of Cocoanut meal, Soy bean meal, Linseed meal and Cottonseed meal.

Cottonseed meal was included as 25 percent of the diet in these trials. The other plant products were included at various levels so that each furnished the same amount of protein as the cottonseed meal. The levels employed were cocoanut 43, linseed 25, and soy bean 21. These diets all included 30% beef liver, 3% mineral mixture, and 2% cod liver oil. The rest of the diet in each case was made to 100% by the use of dextrin. At the end of these trials lasting 24 weeks the average weight for the cottonseed meal group was over 20 grams, for the cocoanut meal group about 14 grams and for the soy bean group 8 grams. Those fed linseed meal died with symptoms of poisoning in the first four weeks. At the present time there is no explanation for the better utilization of cottonseed meal. This may be due to some inherent superiority or it may be some change that is made in some constituent such as starch in the course of processing. Details of these experiments were published in the Trans. of the Am. Fish. Soc. (1929), page 126.

Better Supplements for Cottonseed Meal Diets.

During 1933 attempts have been made to develop better supplements for cottonseed meal diets. The following mixtures were fed to separate groups containing 1250 fingerling trout in each:

Diet No.	Dry Skim Milk	Cottonseed Meal	Fresh Beef Liver	White Fish Meal	Salmon Egg Meal
72.....	25	25	50	—	—
73.....	29	28	15	28	—
74.....	25	25	50	—	—
75.....	—	25	50	—	25
76.....	29	28	15	—	28

In this series No. 76 proved to be the best combination. At the end of the experiment the mean weight for No. 73 was only slightly more than 7 grams while this value for No. 76 was about 13 grams. The other diets produced intermediate values. Thus salmon egg meal provides a satisfactory combination with dry skim milk and cottonseed meal. In this combination the very low level of 15% of fresh meat proved adequate. The details of these experiments are now in press and will appear in the Report from the Cortland Hatchery for the Year 1933, New York Conservation Department, 1934.

The Growth of Different Trout Species upon Diets Containing Cottonseed Meal.

The relative growth rates of rainbow, brook, and brown trout have been compared when they were fed a diet consisting of equal parts cottonseed meal, fresh sheep plucks, and dry skim milk. Later we shall describe the growth of trout in its relation to species. In the present instance it is worth noting that each of these species makes a moderate growth upon this mixture. The differences we have found are probably inherent in the species rather than related to the feedstuffs. Thus far we have no evidence from our experiments that trout species differ in their nutritional requirements, although this may be the case since we have not designed experiments to test this hypothesis, specifically.

Cottonseed Meal in the Diet of Fry.

In one experiment in which fry were fed from the beginning upon a mixture of dry skim milk, cottonseed meal, and fish meal (2:1:1) supplemented with a diet containing fresh meat one day per week, the growth was subnormal during the first three months. After this it became normal until it equaled our better diets. It is questionable if anything is gained by the use of such a feedstuff in these early stages.

Possible Effect of Cottonseed Meal on Breeding Stock.

Unfortunately no experiments have been completed on a sufficiently large scale to determine whether or not cottonseed meal may injure the quality of trout eggs that are to be hatched. In a recent number of Science, Schaible has described ex-

periments at the Michigan State College in which egg yolks produced by poultry fed cottonseed meal are very much modified.

It is therefore well to call attention at this time, to the fact that dried products such as cottonseed meal should be used with common sense, and that the man desirous of producing the best quality of trout eggs should not shift from proved foods merely to save money until more is known about the new foods. For rearing young fish to be planted or marketed cottonseed meal is a good cheap product to investigate.

FAT IN TROUT FEEDS

Fats in trout feed are usually regarded with slight favor by hatchery-men. The question is often asked, "Can trout digest fat?"

Before giving the results of experiments designed to answer this question let us consider for a moment what is meant by a fat. The biochemist used the term "fat" to include such solids as lard, butter, tallow, "Crisco", and such liquids as linseed and cod liver oil. Of course the "solid" or "liquid" condition is dependent upon the temperature. Butter, although a solid fat at room temperature becomes a liquid in our mouths. In order to be easily digested then, fat must be rendered "liquid" by the body temperature of the animal which eats it. The digestion itself is a complicated process depending upon the fat being broken up into very fine particles, or an "emulsion", by the aid of the bile. The cream in warm, fresh milk illustrates a natural emulsion and as such is one of the easiest fats to digest in this condition.

When it is considered therefore that a trout's normal body temperature is lower than the melting points of the animal fats included in the usual hatchery food, there is great doubt that the trout's digestive system can make use of them efficiently. The following table illustrated this contention.

Melting Points of Various Fats in Relation to Body Temperature of Trout

Fat	Melting Point Degrees Fahr.	Exceeds the body Temp. of trout at 50 F. by
Butter	82 - 95	32 - 45 degrees
Horse fat	68 - 113	18 - 63 "
Lard	84 - 109	34 - 59 "
Mutton tallow	111 - 120	61 - 70 "
Beef tallow	108 - 118	58 - 68 "
Stearin	160	110 "

In addition to difficulties in temperature, we note that the Frenchman, C. Raveret-Wattel, author of La Pisciculture Industrielle, says that trout fry cannot

digest fats because the pancreas is not developed. He furthermore advises that no horse fat be fed to breeding trout as it interferes with satisfactory reproduction.

At the last meeting of the American Society of Zoologists, 1933, Dr. Hess of Hamilton College reported and demonstrated marked degenerative changes in the pancreas of overfed trout. This suggests the possibility of distinct injury.

It must not be assumed that fat is not present in the bodies of trout. Quite the contrary. If the fish are dried and the fat extracted it is found to be a yellow oil which will flow at 50° Fahrenheit. This furthermore serves to illustrate the task imposed upon the trout's digestive organs when it must convert lard, a solid fat, into its own body fat. Lard, of course, is the same pig fat which is present in the pork products used in hatchery feed. Even such things as beef liver, beef lungs, and lean meat contain a surprising amount of fat.

In this respect Mr. E. R. Hewitt suggests the possibility that salmon oil is a food admirably suited in its physical nature for trout feeding.

Experimental:

There are several possible ways of determining whether or not trout can digest and absorb specific fats. The best of these is to measure the fat eaten and the fat excreted. The difference gives the fat absorbed and burned or stored in the body. We have made little progress thus far using this method because of difficulties in technic and lack of special apparatus.

Konig and co-workers in Germany (Z. Nahr. Genussm. 23, 177, 1912) found carp sensitive to the kind of fat fed. A difference in the taste and in the chemical nature of the body rat was evident. As carp live in warm waters where the body temperature of the fish approaches the melting point of fat more closely they would appear to be better test animals. The type of experiment, however, gives qualitative results only.

In 1931 (Trans. Am. Fish Soc. 61, 58) a table was presented showing the amount of fat in the bodies of trout fed various diets. In this table are also given the iodine numbers for these body fats. The iodine number is one means of characterizing fat. It is merely a number which shows the weight in milligrams of iodine that will combine with a gram of fat. Fish oils usually have very high iodine numbers while the common food fats have low ones. Thus cod liver oil may have an iodine number of 168 while butter has a low value of only about 38. Some values for the iodine numbers of the body fat of trout are shown in the following table:

Diet Fed	Samples analyzed	Mean Iodine Number	Range of Iodine Nos.
Beef liver	10	107	93-119
Haddock flesh	11	96	92-104
Haddock flesh 3, beef liver 1	7	90	84- 94
Haddock residues	6	105	98-118
Haddock res. 3, beef liver 1	9	109	103-111

Thus trout have what is termed a soft body fat. This is shown by both the relatively high iodine numbers and the liquid condition described previously.

During the past year three groups of trout were fed as follows:

Group No.	
26	Standard hatchery feed 3 parts plus low melting oil 1 part.
27	Standard hatchery feed 3 parts plus solid fat 1 part.
26-27-A	Standard hatchery feed only (restricted in intake).

The standard hatchery feed used was a mixture of equal parts by weight of dry skim milk, cottonseed meal, and fresh sheep plucks. At the end of eighteen weeks upon these diets 6 trout from each group were killed and the iodine number of the mesentry fat determined. Group 26 upon the oil showed values of 100-109; group 27 fed solid fat (Crisco) showed values of 90-95; the values for 26-27-A were 89-100. This indicates that the oil fed group 26 caused a fat with a higher iodine number to be deposited. Thus some of these fats must have been utilized but we do not know the amount.

When the growth of the trout on these diets was compared after 32 weeks feeding no conclusion could be drawn concerning the fats or oils for the growth curves were identical. A later experiment of 18 weeks duration substantiated these observations.

A long series of trials were then made in which the amounts of fat eaten and the amounts excreted by trout were measured by analysis. Oils such as salmon oil and cottonseed oil were utilized to the extent of about 80-90 percent while hard fats fell as low as 50 percent. The plant oil was as well utilized as the salmon oil. In these trials, levels of both 7 and 25 percent of the diet were employed. In both levels, the trout were able to use about the same percent of the fat. (Detailed data from these experiments will be found in the Report from the Cortland Hatchery for 1934, New York Conservation Department, Albany.)

CALCIUM IN THE DIET OF TROUT

A great Swedish chemist, Carl Wilhelm Scheele, some 150 years ago, discovered that animal bones were chiefly calcium phosphate. Other chemists took up the study of bones and soon men were greatly concerned with the problem of what foods an animal should eat in order to build strong bones.

In all their investigations along this line, it is surprising that little attention has been given to the composition of fish bones, especially when we consider that fish is one of the few animal foods able to supply us directly with calcium, as witnessed in the eating of canned salmon.

Nevertheless we, today, profit by these early experiments. We feed more milk to children; bone meal to swine and cattle, and oyster shell to chickens. Considerable care is taken to insure an adequate supply of calcium in the diets of all growing animals, but no fish culturist has found it necessary to feed calcium either as bone meal or limestone as a supplement to the usualy hatchery diet.

The question then arises, do trout need calcium? Must they get it from their food or can they take it from the water in which they swim? Are weak trout with weak bones produced if the water is deficient in calcium and the food does not supply it? How low must the water calcium level be before the trout suffer from calcium deficiency? How can the fish culturist insure an adequate supply of calcium in his feeds? Part of these questions can be answered today, part cannot.

Calcium and Phosphorus in the Entire Bodies of Brook Trout.

In 1931 we analyzed the entire bodies of brook trout which had been fed different diets and found that the amount of calcium and phosphate in the fish was practically the same on all diets regardless of whether or not any special diet was more rich in these elements. Furthermore, more calcium was present than the food eaten could possibly have supplied.

The only possible source of this calcium thus appeared to be the water in which the fish swam. Other investigators have found that different animals secure calcium direct from water, so why not trout?

Accordingly in 1933 we ran a direct experiment to determine how much calcium trout could absorb from the water in 12 weeks. Three groups of 50 brook trout each were selected and half of them killed at once and their bodies analyzed for calcium. The rest of the fish were fed for 12 weeks on a measured amount of preserved liver having a known calcium content. At the end of 12 weeks the test fish were also killed and their bodies analyzed and compared with the fish that had been killed earlier.

It was found that although the fish had gained little in total body weight that their bones had continued to grow, showing that calcium storage continued. Each trout has stored from 5.4 to 6.2 milligrams of calcium of which FOUR-FIFTHS was taken

directly from the water, for the food eaten was able to supply only ONE-FIFTH because of its limited calcium content from the start. This was direct proof that trout were able to take calcium from the water.

A second experiment was run in 1935 following the same methods except that eggs were analyzed one day after they were taken from the female. Monthly analyses were then made for eleven months, until the average weight was 5.5 grams per trout. In general this gave the same picture of the absorption of calcium from the water. In addition it showed that the young fry starts building bones about the time it starts eating. Before this period the body has much more phosphorus than calcium but the calcium gains until it practically equals the phosphorus. (Details can be found in Cortland Hatchery Report No. 4.)

If the hatchery water is hard (rich in calcium) the hatcheryman need not trouble himself about supplying extra calcium to his fish for the purpose of building bones, for it is evident that any such deficiency in the feed can be overcome naturally by the fish which obtain it directly from the medium in which they live, but if the hatchery water is very soft it may be necessary to vary the diets to supply the deficiency.

VITAMINS AND TROUT FEEDING

At the present time there are some hatcheries that are feeding such products as yeast and cod liver oil. We have never found any experimental evidence, however, that such feeding practices are justified. In the course of the past seven years we have carried out at least 40 experiments involving yeast and cod liver oil. We have never obtained evidence that the use of either of these supplements adds anything to a diet that consists partly of fresh meat.

Our attitude toward the feeding of such products as yeast and cod liver oil to trout does not imply that trout have no vitamin requirements. Quite the contrary, for we have a mass of evidence that trout do require vitamins.

As far as practical feeding in the hatchery is concerned we must conclude today that there is no justification for the feeding of such supplements as yeast and cod liver oil.

FEED CONVERSION BY TROUT

As the hatcheryman is most concerned in the growth of his trout, he is greatly interested in finding feed mixtures that will produce the most pounds of trout on the fewest pounds of feed. In other words the ability of the trout to CONVERT their foodstuffs into body tissue is of prime importance to him.

There are various methods for determining how much feed is changed into the body of an animal. The first method deals with chemical balance, such as described above under the protein requirements of trout in relation to nitrogen. Another

method already mentioned consists of analyzing the bodies before and after keeping them a certain time on a known diet. The third method is that familiar in every hatchery; namely, weighing the fish at the beginning and end of a given time and determining the weight of feed eaten. Finally, the amount of feed eaten is divided by the increase in weight of trout. This gives the pounds of feed needed to make one pound of fish. This method is the most useful in the practical hatchery because it is simple and can be used where the services of chemists are not available.

The greatest error in the use of this method comes from disregarding the water present in the feed employed. Thus 20 pounds of a feed made by mixing 10 pounds of fresh beef liver with 10 pounds of dry skim-milk will contain about eight pounds of water, while 20 pounds of beef liver alone will contain 14 pounds of water. This huge error is corrected by converting these feedstuffs to a moisture free basis. The amount of dry feed to produce a pound of trout can then be determined. This is quite accurate as long as the diets fed are not high in either fat or indigestible material such as crude fiber. This conversion can also be expressed in terms of protein or calories if the composition of the feedstuff is known. Since most diets used in the hatchery are low in fat and fiber the conversion into terms of dry feed is satisfactory. This failure to consider the moisture of feeds is found in reports from Germany, France, and England as well as those from America.

Many investigators such as Cornelis (Zeit. Fischerei 31, 536, 1933) have inquired into the problem of how many pounds of food it takes to produce a pound of fish, but there was no uniformity in their methods, some using the wet weight of the food and others the dry. A great variety of results has been obtained therefore both in Europe and at home. It has required from 1.5 to 15 pounds of food to produce a pound of trout depending on the nature of the food itself.

Other things that influence the ability of trout to convert their food into body tissue are water temperature and the oxygen content of the water. Investigators have found that abundant oxygen was necessary and that a temperature ranging from 44 to 52 degrees F. permitted the best food conversion.

If we wish to really determine conversion we must consider water in the animal body. In our analyses of the entire bodies of brook trout we found them to be one-fifth dry matter and four-fifths water. (Trans. Am. Fish. Soc. 61, 58, 1931.) If five pounds of fresh liver must be fed to produce a pound of live trout and if this fresh liver is three-fourths water it requires slightly more than six pounds of "dry" liver to yield a pound of "dry" fish. Under these very favorable conditions about one-sixth the food eaten is changed into the body of the trout and five-sixths of the food is used to keep the heart beating, the intestines moving, and to supply energy for swimming.

In 1929 (Trans. Am. Fish Soc. 59, 126) we reported a series of experiments in which we measured the feed intake and the gain of brook trout during the growing period of one year. The feed conversion was then calculated for periods of four weeks each. In the course of seven such periods with a group of trout fed a mixture

of fresh beef liver and dry skim-milk in a ratio of 61:37 with a supplement of 2 percent cod liver oil, and daily feeding of yeast the dry feed required to produce a pound of live trout varied from 1.2 to 2.2. The calories contained in a hundred grams of each of the substances involved in these trials were approximately the following:

Number of Calories and Moisture Content in 100 Grams of Different Foods

	Calories	Moisture %
Fresh beef liver....	119	72
Live trout.....	112	78
Dry skim milk.....	352	6.6
Cod liver oil.....	930	----

If the percent moisture of a substance and its heat value in calories is known, the calories on a dry basis may be figured. Fresh beef liver served as a good example. In a hundred grams of fresh liver there must be 100-72 - 28 grams of dry material. Since water cannot be burned to furnish heat, the calories of liver must all be due to the dry portion. Then the 28 grams of dry material must furnish all the heat available when the animal body burns 100 grams of fresh liver or 119 cals. If 28 grams of dry liver furnish 119 calories, one gram will furnish 4.25 cals. or 100 grams of dry liver will yield 425 calories.

In the above feeding trials the feed used was a mixture of fresh beef liver 61, dry skim milk 37, and cod liver oil 2, with yeast fed separately in an amount equal to about one-fourth the weight of this diet. This feed on a moisture free basis contained 387 calories per 100 grams. The average for the 7 conversion ratios whose range is given in the paper referred to was 1.6 or in other words 1.6 grams of the feed on a dry basis was needed to make a gram of live trout.

To find the calories in the feed converted into calories of trout body we multiply 1.6 x 387 — 619 calories of feed required to make a hundred grams of trout. In the above table we noted a 100 gram trout contains 112 calories. Thus 619 cals. of feed were converted into 112 cals. of live trout. Approximately 18% of the calories are converted by the trout.

These calculations allow the same conclusions as those previously, namely, that about one-sixth of the dry feed allowed a brook trout, can be converted into body tissue under favorable conditions. For practical purposes there is no need to know more than the dry feed used and the gain in body weight by trout.

The chief error in these figures lies in the loss of nutrients dissolved in water in the course of feeding the trout. They were fed in troughs with running water. Therefore all the feed lost makes the conversion by the trout appear more

unfavorable. This figure of 18% compares favorably with that for the better converters among farm animals in spite of the fact that it is too low.

Some of the German workers have claimed there is a direct relation between the protein content of a diet and the efficiency of the trout in its use. Our data of 1929 afford no basis for this relation. In these experiments, diets were used that varied in protein from 19 to 61 percent.

Trout require 10-14 percent protein in their feed to make optimum growth. Any protein level above this should tend to give less efficiency in feed conversion because protein exerts a specific dynamic effect in trout just as it does in higher animals. In other words the trout body generates more heat after protein feeding than it would after a similar feed of carbohydrate. This was shown by the metabolism studies of Linstedt, (Zeit. F. Fischerei 14, 193, 1914).

From the relatively slow growth of brook trout compared to higher animals such as swine one would expect the trout to be a much poorer converter of feedstuffs. The trout, however, has some advantage, inasmuch as it does not need to keep its body warm.

Lindstedt found that trout need about 0.215 liters of oxygen per kilogram of body weight per hour at 15° C.

Recent Experiments:

More extensive data concerning the problem of feed conversion have been secured at the Cortland Hatchery during the past year. These data are presented in detail by us in the Report of the Experimental Work at the Cortland Hatchery for the year 1933, Albany, N. Y. The composition of the more satisfactory diets is shown in the following table:

Diet Number	72	73	76	77
Skim milk	25	29	29	29
Cottonseed meal	25	28	28	—
Raw beef liver	50	15	15	15
White fish meal	—	28	—	28
Salmon egg meal	—	—	28	28
% Protein (dry basis)	45	46	41	47

The conversion values for these various diets are summarized in the following table:

Diet No.	72	73	76	77
Number of 4-week periods used	4	6	6	4
Average number of trout used	1060	1123	1122	1060
Weight of group (start)	5614 g.	4142 g.	6123 g.	6107 g.
Gain in live wt. per 4-week period per group	1618 g.	1045 g.	2122 g.	1957 g.
Grams of dry feed per gram gain in live weight. (Average F. C. — Feed Coefficient.)	2.6	4.9	3.4	3.3
Extremes of F. C.	2.0-3.6	3.3-6.4	2.5-5.5	2.6-4.1
Av. Feed Cost per pound of trout produced	$0.32	$0.29	$0.31	$0.30
Feed Cost Extremes	0.23-0.42	0.18-0.45	0.22-0.47	0.23-0.37

More diets are considered and more data are given in our published report.

These figures upon the cost of production are much lower than we obtained in the same series of experiments in a trial with beef liver. This is a slight consolation, however, when we compare the cost of producing trout with that for swine. The farmer that spent $30 to produce each hundred pounds of pork would not remain in business very long. We have made real progress during the past years in feeding trout but we still have a long distance to travel until we reduce this cost figure to three to five cents per pound. It is improbable that we will ever be able to feed trout as cheaply as swine but it is certain that we will learn to feed them much more cheaply than we are doing at the present time.

The fourth year has now been completed in which brook, rainbow, brown and lake trout have been reared in parallel troughs upon diets of similar composition. The growth curves for these species have run parallel, but the lake trout have proved consistently more efficient in feed conversion.

The problem of the amount of feed that should be employed to give optimum results has been given much attention during the past two years. There is little doubt that trout fed 5 percent of their body weight daily use the feedstuff more efficiently than those allowed 10 percent. On the other hand, the lower level slows down the growth rate, and the season ends with smaller fish. In the end it reverts to what the hatchery can afford. Details of these experiments appeared in Cortland Hatchery Report 4 for the year 1935.

THE COLORING OF TROUT

We have devoted the preceding pages to a discussion of what foods can be used profitably to promote growth in hatchery fish. We must not forget at the same time, the real purpose of fish hatcheries, which consists of providing trout for the anglers to catch. The hatcheryman wants quick-growing healthy fish in the interest of economy. This suits the angler also. The sooner fish reach a good size for planting the better he likes it, but he also wants to catch trout that look like

trout and that act like trout. All too often the contours, actions, and especially the colors, of hatchery trout are a long way from the wild trout of the open water.

In 1916 Prince presented a non-technical summary of the problems involved in pigmentation of trout. (Trans. Am. Fish Soc., — 46, 50. — 1916.) He noted that the feed of the trout influenced this coloring, but that no one had been able to color trout consistently by feeding. He also noted the variability in color of fish from the same school and concluded that there must be inherited differences. Before this date it had been claimed that a highly colored female produced eggs of deeper color. Finally Prince repeated the familiar statement of the old as well as many modern zoologists that the coloring materials were merely waste products that the animal body cast off and used in exterior decoration. This last theory which is very old should be kept in mind in order to appreciate the changes that have taken place today as a result of a much better knowledge of the biochemistry of natural pigments.

Before summarizing our own experiments to isolate the material in salmon eggs responsible for the coloring of hatchery trout, a brief discussion of the common coloring materials might prove interesting.

Lipochromes or Carotinoids:

The natural coloring matters that are soluble in fats are familiar to everyone. The yellow cream from the Jersey cow, the yellow yolk of the egg, the yellow color of carrots, the brown color of autumn leaves, the reddish color of salmon oil or salmon eggs are all familiar examples of fat soluble pigments that are called "lipochromes" or "carotinoids". Many of these coloring materials that are soluble in fat were studied 100 years ago. The great Swedish chemist, Berzelius, (1779-1848) tried to isolate the brown coloring matter from autumn leaves. He failed, but in the year 1831 the yellow coloring matter from carrots was isolated in beautiful crystals. Little did these early chemists dream of the interest the modern age would take in their discoveries.

The reason for this modern interest is the discovery that this yellow substance from carrots can be changed by the animal body into vitamin A. As far as known all higher animals must have this vitamin A in their diet. Without it they first develop sore eyes, then go blind, and finally die.

This relationship between the coloring materials of plants and animals and the essential vitamins has led to the realization that the coloring matters of animals are vital to life processes and all of them are not merely excreta which the animal has learned to use for adornment. Thus the possibility is created that rearing trout that are well colored is desirable in the interest of producing healthier fish as well as more beautiful specimens.

Practically all of the better known coloring materials are spoken of as being fat soluble, which means that they have a marked affinity for combining with various fats. For many years, the feed has been known to influence the color of the cream produced by cows. Yellow corn, green grass, and carrots make cream a deeper color.

By use of fat soluble dyes Gage and Fish (Am. J. Anat. 34, 1 — 1924) showed that they were not only able to dye the fat in milk but to induce the same color in the body fat of any young animal that drank the milk. Chickens fed pimento pe pers at the Georgia Experiment Station had more color in legs, combs, and in the yolks of the eggs produced.

The German chemists first isolated the important animal pigment, ASTACIN. This pigment occurs in the muscles of salmon and probably in the eggs. It has also been isolated from the livers of several species of fish. Sorensen found it in salmon oil. It has also been isolated from natural fish feeds such as decapods and crustacea. The biochemists have thus assumed that fish acquire this pigment from feedstuffs but have failed to provide proof based on experiment. There are other pigments in salmon eggs of unknown composition such as the "salminic acid" of the Swedish workers. For further details concerning the chemistry of these compounds the Annual Review of Biochemistry should be consulted.

All the experimental evidence therefore pointed to the possibility that color in trout depended upon a fat soluble pigment.

Cortland Hatchery Experiments: Pigment Extracts.

In order to isolate the material in salmon eggs responsible for the pigmentation of trout, 20 pound lots of dried salmon eggs were placed in a continuous extractor and extracted repeatedly with 95% alcohol until little pigment was observed to pass over at the time of siphoning. A considerable amount of color remained in the eggs and appeared to be insoluble in alcohol. The alcoholic solution was concentrated to a dense reddish black solution which was very bitter to taste. Brook trout were placed upon a diet of cottonseed meal 1, fresh beef liver 2. These were divided into 2 groups. One diet was augmented with a 4th part of the salmon egg residue and another with the alcoholic extract about equal to that taken from the eggs. The experiment was run for 44 weeks. Trout were started at a mean weight of 2 grams and ended with a mean weight of 15 grams. The growth rates of the 2 groups were the same. The trout fed the colored extract developed a marked color starting at about the 8th week while those fed the residue formed little if any color. This experiment indicates that the colored material can be dissolved from the salmon eggs and that it is probably a lipochrome or a fat soluble color similar to those discussed in the preceding pages.

Conclusions:

It is possible to color trout by appropriate feeds just as it is to pigment the eggs of chickens or the milk of the cow. The important pigments that serve in this capacity are probably fat soluble ones. A bare beginning has been made in introducing such pigments into the bodies of trout. By isolation methods it is likely that the effective pigments can be studied and cheaper sources for them located. These lipochrome pigments probably play an important part in the development and physiology of trout just as they do in providing sources of vitamin A for higher forms such as man and his domestic animals.

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THE INFLUENCE OF NATURAL CONDITIONS ON THE GEOGRAPHIC DISTRIBUTION OF THE PACIFIC SALMON

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IT WAS the dream of our early propagationists, who began their work some 65 years ago, to fill the waters of every land with the highly prized Pacific salmon. The story of their many attempts to accomplish this task shows that environment or natural conditions must be considered and that it is very seldom Nature can be beaten.

Under the able direction of Prof. Spencer F. Baird, Mr. Livingston Stone was dispatched to California to undertake the task of collecting and preparing for shipment eggs of the Pacific salmon. In those old horse-and-buggy days his means of transportation were limited and time consuming. He not only had to be a fish culturist, a biologist, a linguist, and a prophet; he had to be a pioneer — pioneer in his field and pioneer in the West. The West had not yet been won and as soon as one set foot outside the newly populated centers he came in direct contact with the wild and woolly. Peace had to be established with the Indian tribes which inhabited the river valleys. They could not understand the reason for the white man's interference with one of their valued food supplies. This, Stone accomplished, and to his credit standards the establishment of the first egg-taking station in the West. In 1872, the first western salmon-breeding station in the United States was established at a location 22 miles from Redding, California, on the McCloud River, a tributary of the Sacramento River. It is still operating and bears the name, Baird Station.

From this humble beginning, the collection and distribution of Pacific salmon eggs has grown to enormous proportions. Countries in almost every continent of the world requested eggs and fry of the Pacific salmon with which to stock their coastal waters. In the wholesale stocking that followed, many of the fundamental laws of nature were ignored or ruthlessly broken.

Throughout the 20 years that followed the opening of the Baird Station, the eggs of chinook salmon were the only ones shipped for transplantation in foreign waters. Like all valuable natural resources, the chinook salmon in Sacramento River were utilized to a greater and greater extent with the result that their abundance began to decline, and egg collecting stations had to be established at other points along the Pacific Coast. Additional fish hatcheries were established by the Bureau of Fisheries on a number of the salmon streams in Oregon and Washington, the majority of which were located on streams tributary to the Columbia River. Following 1900, the hatcheries of the Pacific coast states and Alaska formed the source of supply of millions of eggs of the other species of Pacific salmon that were likewise shipped to various parts of the world for transplantation.

Information regarding the outcome of the many transplantations was unfortunately never recorded. In an attempt to secure this information letters of inquiry were written in 1936 to all states and foreign countries receiving shipments of Pacific salmon stock for transplantation in their coastal streams. Each letter contained a statement of the egg shipments made to the respective state or country and requested information concerning their ultimate success or failure.

The replies received from 28 of the 30 fish cultural agencies regarding the survival of these transplants were very meager. Only a few states and countries made direct statements indicating the development of sea-run salmon populations in their rivers. Others reported negative results or professed no knowledge of planting activities carried on in the past. A few requested shipments of stock and stated that they would keep the Bureau well informed as to their progress and the development of a sea-run salmon population.

The early transplantations of the Pacific salmon were made without regard to the suitability of the waters for the natural development of the salmon. This was an unfortunate circumstance, but it could not be avoided at the time for very little information was then available to the fish culturist concerning the natural conditions of the native habitats of the salmon. With the lapse of time, however, studies have been made and it is now possible to make a relative evaluation of the natural conditions found in the waters in which the Pacific salmon are native and to which they have been transplanted. Although this study is not complete, the results should provide a tangible basis upon which to judge the suitability of new waters in future transplantations.

NATIVE DISTRIBUTION

The native distribution of the Pacific salmon is confined to the temperate and arctic waters of the North Pacific Ocean and is fairly well defined. The series of parallel bars shown in the accompanying figure along the North American and Asiatic continents, defines the coastal areas inhabited by the Pacific salmon. On the North American continent the Ventura River, 60 miles west of Los Angeles, California, may be designated as their southernmost limit of occurrence. From the Golden Gate on the south to Kotzebue Sound in the north, the salmon are found inhabiting the coastal streams in varying degree of abundance.

In the Arctic Ocean the salmon are known to enter the Mackenzie and Lena Rivers, but information regarding other localities of distribution is very meager. The Arctic Ocean in general acts as a barrier to distribution because of severe conditions that must be encountered.

Along the Asiatic coastline the Pacific salmon are distributed from the Anadir River in northeastern Siberia that empties into the Bering Sea, to the Tumen River in northern Korea that flows into the Japan Sea. They are also present in the coastal streams of Sakhalin and Hokkaido Islands and in the streams along the eastern and northern shores of Honshu Island. The salmon are found entering the coastal streams throughout this 20,000-mile expanse of coastline and in a great number of localities they are of great commercial importance. The Tumen River seems to mark the Asiatic southern limits of occurrence as distinctly as the Ventura River forms the southern limit on the North American continent.

Necessary Requirements in Native Fresh Waters.

The fresh water conditions which the salmon invariably seek during their spawning migration consist of clear, cool and well-aerated water running sufficiently swift over shallow riffles of a clean gravelly streambed. The majority of the streams frequented by the salmon in the native habitats are mountain streams fed from springs, glaciers, or snow deposits. All are influenced by local rainfall, which not only affects the rise and fall in stream level, but is occasionally responsible through erosion for silt in the water. The presence of excessive amounts of silt may in-

fluence normal respiration in the adult salmon as well as cause destruction of the eggs through suffocation.

Environmental Factors of Native Marine Habitats.

Since very little is known of the regions frequented by the salmon in the sea no definite information has been available concerning the natural factors that influence their activities during this phase of their life history. However, from attempts to transplant the Pacific salmon in foreign waters, information has been gained concerning some of the natural factors that may influence their distribution in the sea and their subsequent return to the streams in which they were liberated. This information has been derived through a comparative study of the ocean currents and associated surface and sub-surface temperatures and surface salinities (salt content).

The geographic limits of distribution of the salmon are related to the presence of cold and warm currents. This relationship was of most apparent significance during the spawning migration. Thus the direction of the currents during the months of June, July, August, and September in the northern hemisphere and the months of January, February, and March in the southern hemisphere was used as a basis for illustrating this relationship. Those currents which are of tropic or arctic origin carry with them the environmental conditions as found in each respective region and tend to distribute those conditions over a large intermediate area. Here are to be found the governing factors which determine the type of life each will support and over what area its influence is dominant.

Off the coast of Japan where the warm currents from the south are met by cold currents from the north the limits of the native distribution of the salmon are clearly defined. Here a surface temperature of 15° centigrade (59° F.) is encountered along with a sub-surface temperature of 10° (50° F.) at a depth of 200 meters and the salinity or salt content ranges between 34 and 35 parts per thousand. As the currents move from west to east across the Pacific Ocean the contours depicting the average temperature and salinities follow in a related manner. As the current reaches the coast of North America it divides off Vancouver Island into two branches, the northern branch flowing into the Gulf of Alaska and the southern branch bathing the shores of Washington, Oregon and California before it turns westward again to join the tropic drifts. The temperature and salinity contours veer to the southward with the current, and off the coast of southern California the 15 degree surface, 10 degree sub-surface temperature and the salinity of 34 parts per thousand are found to border the southern limits of distribution along the American coastline as they do along the Asiatic coastline. Within the native distribution the surface temperatures range from slightly above freezing to 15° centigrade; the sub-surface temperatures range from 0° to 10° centigrade and the salinities average around 32 parts per thousand.

FOREIGN DISTRIBUTION OF THE PACIFIC SALMON

Origin of Stock and Localities of Transplantation.

With the first shipment of Pacific salmon eggs from the Baird, California station in 1872 for transplantation into foreign waters, problems arose in regard to the methods to be used for shipment and subsequent propagation. Information was available concerning hatchery routine as it was then carried on along the eastern coast and in foreign countries. Various species including trout were being propagated and transplanted into new localities but no attempts had heretofore been made to propagate and distribute stock of the Pacific salmon. Despite the handicaps under which the early salmon culturist had to labor, the number of eggs shipped annually for transplantation increased at a tremendous rate. Within the seven years following 1872 the annual shipment of salmon eggs had risen beyond ten millions. In this short period of time eggs had been distributed to more than thirty-seven applicants in the United States and foreign countries. The ability to send eggs more than half way around the world and across the equator was an accomplishment of great importance. The task alone of keeping the temperature of the eggs within a proper range was just one of the many difficulties with which the early fish culturist had to cope. It is known that many shipments of eggs perished due to improper refrigeration, inadequate transportation facilities, unsuitable packing and handling, and the lack of proper hatching facilities after arriving at their destination.

During the first 28 years of this experimental work, plantings were made in numerous and diverse waters in many parts of the world, but not a single natural run was established. After the turn of the century all species were handled and during the 30 years that followed some of the transplantations resulted in the establishment of natural runs in a few of the foreign habitats.

The localities of foreign transplantation are shown in the accompanying figure. The dotted areas indicate the localities where stocking of foreign waters was attempted but without result, and the solid black areas, of which there are only four, indicate localities in which have developed successful sea-run populations. In every successful transplantation the environmental conditions encountered were similar to those found within the native distribution. Upon close examination of the figure it will be seen that in each region where dots indicate failure of the transplants the environmental factors encountered exceeded in one or more instances the limits of tolerance of the Pacific salmon in their native distribution.

Survival of the Transplants in Foreign Waters.

The history of the survival of transplantations of Pacific salmon in foreign waters as described by the statements taken from letters of reply is very meager. In the United States, Maine is the only state reporting the establishment of a sea-run population. Pink salmon (O. gorbuscha) planted in the Dennys, Penobscot and Narranguagus Rivers have developed sea-run populations, but unfavorable sentiment by the residents against them has contributed to their near depletion in these waters.

WORLD DISTRIBUTION OF PACIFIC SALMON
WHERE PACIFIC SALMON ARE NATIVE
WHERE TRANSPLANTATIONS HAVE FAILED
WHERE TRANSPLANTATIONS HAVE SUCCEEDED
INDICATE DIRECTIONAL DRIFTS OF OCEAN CURRENTS
AVERAGE SURFACE TEMPERATURE CONTOURS
AVERAGE SUBSURFACE TEMPERATURE CONTOURS
AVERAGE SALINITY OR SALT CONTENT CONTOURS
5°
3°
15°
34
10°
35
5°
35
5°
10°
15°
10°
35
15°
34
5°
5°
34
5°
35
15
10°
5°
34

At one time during the development of these runs the Bureau of Fisheries fish culturists spawned eggs from the newly introduced sea-run populations in Maine for distribution to nearby waters.

Reports from Canada reveal the presence of chinook salmon (O. tschawytscha) in Lake Ontario. The chinook salmon have been taken in the St. John River, New Brunswick and the Port Credit River, Ontario. In the St. John River they have been taken by the hundreds and vary in weight up to 8 pounds. The runs in the Port Credit River are of recent date. Chinook salmon that weighed up to 30 pounds were taken from this river in 1925. The milt and eggs were reported to be well developed and it is assumed that they migrated from the sea up the St. Lawrence River and through Lake Ontario to spawn in the Port Credit River. Other streams tributary to Lake Ontario on the St. Lawrence River may maintain small runs of chinook salmon which to date have not been identified. Maine, New Brunswick and Ontario are the only regions on the North American continent where foreign populations of the Pacific salmon have been established.

The natural conditions in the streams and lakes along the Atlantic coast north of the State of Virginia would indicate that these waters provide the important physical characteristics for the survival of the salmon during their fresh water life history. This has been illustrated not only by the establishment of runs in Maine, New Brunswick and tributaries of Lake Ontario, but also by the survival of landlocked populations in lakes throughout this region. It is not improbable that the failure of the transplantations of the Pacific salmon to develop sea-run populations in the coastal streams from Virginia to the Gulf of Maine may have been due to the unfavorable marine waters of this region. However, the failure in the warm coastal streams of Virginia, North Carolina, South Carolina and Georgia, and especially in the warm and muddy Gulf streams of Louisiana and Mississippi may be definitely attributed to the unfavorable natural conditions in these streams as well as to the unfavorable conditions in the marine waters throughout the region.

The natural marine conditions, as shown in the accompanying figure, along the Atlantic Coast where transplantations have been made are only found to be suitable for the Pacific salmons north of Cape Cod. Streams in which sea-run populations have been established are the coastal streams flowing into marine waters that are dominated by cold currents from the north. Marine conditions at Cape Cod are similar to those found on the southern limits of the native range. Both the 15° centigrade surface contour and the 10° sub-surface contour originate in the proximity of Cape Cod and follow the general direction taken by the currents as they cross the Atlantic to reach the shores of Europe.

European habitats have proven unfavorable to all transplantations of the Pacific salmon. All of the northern countries acknowledged receiving the eggs but none could ite a single instance in which the salmon had returned from the sea to spawn in the streams. Many methods of introducing the young into the streams were employed but none proved successful. Hence, from these many attempts, it may be concluded that the establishment of sea-run populations in these waters is very improbable. How-

ever, Finland is at present importing chinook salmon eggs with the hope of establishing the species.

The rivers of Northern Europe, in which thousands of young Pacific salmon have been liberated, but to which no adults have ever returned, all lie within the limits of the native distribution of the Atlantic salmon (Salmo salar), which has similar fresh water requirements for reproduction. With the exception of the artificial barriers and hazards introduced in these streams, it would appear that they all provide the essential conditions necessary for the fresh water survival of the Pacific salmon. Furthermore, many chinook salmon have been reared in both natural and artificial ponds in France, Germany and Holland. In France these landlocked individuals have been spawned artificially for propagation in these waters. Thus, the failure of the Pacific salmon to establish sea-run populations in the streams of Northern Europe appears to lie in the unfavorable environmental conditions that are encountered in the marine waters of this region.

The warm and silt bearing streams in Southern Europe in which efforts were made to establish the Pacific salmon do not provide fresh water conditions suitable for the survival of these fish. Therefore, it is not surprising that the transplantations in these streams were complete failures.

The regions of Europe where transplantations have been made and failed to develop sea-run populations are all bathed by warm currents. In the accompanying figure it will be seen that the temperature and salinity range present in the native distribution of the salmon is exceeded in each instance where transplants were made in European waters.

The establishment of the Pacific salmon in South America has been partially successful in only one locality. Chile reports the probable presence of coho salmon (O. kisutch) or sockeye salmon (O. nerka) running in some of their streams in the southern part of the country. Runs have been reported in the San Pedro River. It has been rather difficult to obtain reliable information about the salmon in Chile, due primarily to lack of scientific surveys throughout the sparsely inhabited regions in which the salmon have been introduced. Argentina states that in their country as in Chile, it has been difficult to secure definite information, due to lack of adequate scientific personnel. Results of the plantings in South America are not known to the full extent, but information that is available limits to the development of sea-run populations to Chile and states that they have legislation now in effect which prohibits commercial fishing for salmon until 1940.

Little is known concerning the environmental conditions in the coastal streams of Argentina and Chile where efforts have been made to establish sea-run populations of salmon. Many of the streams in Argentina receive a great deal of drainage from plateaus and are essentially alluvium bearing streams. The coastal streams in the southern part of Chile are quite similar in origin and character to the streams of southeastern Alaska. Returns of adult salmon have been reported only in the most southern streams in which transplantations were made. This does not mean, however,

that other streams are not suitable for the production of the salmon but merely that no returns have as yet been reported in them. The southern region of Chile, which has proven favorable to the Pacific salmon, is in direct contact with the cool waters of the South Pacific. Although favorable ocean temperatures are found farther to the northward, a lack of suitable streams in this region may dominate the factors influencing the introduction of the salmon.

The only region suitable for transplantation in Argentina is that area throughout Patagonia which is affected by the cool ocean currents from the south. The presence of warm currents along the coast of Brazil would tend to limit the survival of salmons in the same manner as the warm currents have limited their survival in other countries. From a geographical standpoint, the absence of land masses in the South Atlantic acts as a natural barrier to the Pacific salmons. In only one instance, that of South America, does a continent extend into temperate waters beyond the 35° south latitude. In the native range the 35° north latitude is in close proximity with the lower limits of the native distribution. Thus, geographical locations and currents are two outstanding factors governing distribution in South America.

The Hawaiian Islands lie wholly within a tropical environment. The mountainous condition of some of the islands, however, provides watersheds and streams with comparatively cool waters and suitable stream beds. The transplantations of the Pacific salmon in these streams have survived to the stage of seaward migration but no adults have ever returned to the streams. Here it is believed that the unfavorable tropical marine conditions are responsible for the failure to develop sea-run populations.

Although many attempts have been made, Australia and Tasmania report that all transplantations of the Pacific salmon in their waters have failed to develop sea-run populations. Tasmania reported that in the confined waters of the Great Lake the chinook salmon thrive and grow rapidly to support a very desirable fresh water sport fishery. The rivers of both Tasmania and Australia have comparatively warm waters, especially in the lower estuaries. However, the upper reaches of some of the rivers have cool waters and support various species of trout. In view of the warm ocean currents that encompass the shores of both Australia and Tasmania it is very doubtful if sea-run populations would be developed in the coastal streams of these countries even if they were more suitable for the fresh water development of the salmon.

The correspondence received from New Zealand has been the most enlightening. In 1905 the first runs of chinook salmon were observed during their spawning migration in the Waitaki River on South Island. These runs have continued to grow and spread to other rivers on the island and within the past few years they have reached commercial importance. Hatcheries have been constructed and each year there is an abundant egg take. The eggs are hatched and the fry used to restock the parent stream or are planted in other streams favorable to their survival. Eggs spawned and eyed in New Zealand have been transported to Tasmania for transplantation.

Of the four successful regions in the world to develop sea-run populations, New Zealand has been the most outstanding to date. The sea-run populations have

adjusted their life history to the six months difference in season in the southern hemisphere. The spawning migrations of these populations occur in January, February, and March, which are the seasonal equivalents of July, August, and September in the northern hemisphere. New Zealand is composed of two major islands known as North and South Islands. The streams of both islands are quite similar in origin and character. Most of the larger streams originate in high mountain lakes and flow rapidly over gravelly stream beds. The streams are comparatively cool although those on North Island, which has a much warmer climate due to the influence of the tropical ocean currents, may become very warm in their lower reaches during the southern summer. Plantings of young salmon have been made in practically all of the streams on South Island and in many of the streams on North Island. Furthermore, adult individuals have been seen from time to time in the streams along the south shores of North Island but definite sea-run populations have never been established within them. It can readily be seen that the current systems around Australia and Tasmania during the south summer tend to keep both of these countries surrounded with warm waters, but in New Zealand a completely different circulation of ocean currents is present. The cool currents which bathe the shores of South Island, New Zealand during the south summer afford marine conditions similar to those found in the native distribution of the Pacific salmon. These are factors that have no doubt influences the known survival of the salmon that have been planted in this region.

The salinity contour of 35 parts per 1000 passes through South Island at the limits of distribution of the salmon but excludes both Tasmania and Australia. Although the mean annual surface salinities encountered by the Pacific salmon in their native distribution did not approximate 35 parts per 1000, it is quite possible that this figure is their upper limit of tolerance as indicated by their reaction to salinities in New Zealand.

The 10° centigrade contour in the South Pacific completely excludes both Australia and Tasmania. South of Tasmania it swings northward to include the greater portion of South Island, New Zealand. Plants made in southern New Zealand have encountered favorable subsurface temperature conditions in their coastal waters at depths of 200 meters. However transplants made in Australia and Tasmania met with unfavorable subsurface temperatures in their coastal waters. This relationship between subsurface temperature and the areas in which the salmon had been successfully transplanted is similar to that found in other regions where transplantations have been made.

The high surface temperatures encountered around Australia exceed the 15° centigrade surface contour which is associated with the range of successful distribution of the salmon. Although Tasmania lies within the limits of the 15° surface contour, other marine factors may have restricted the introduction of Pacific salmon into its waters. In New Zealand the most outstanding results in establishing natural runs of the salmon have been obtained on South Island, whose coastal waters have surface temperatures comparable to those found within the native waters of the North Pacific.

From the results of these many attempts to transplant the Pacific salmon in foreign waters it is obvious that the North Pacific Ocean is the only extensive region in the world where these salmon may propagate naturally. Furthermore, these attempts have again shown very clearly that environmental or natural conditions must be considered in all stocking programs and especially when they include areas outside the native range of the species. Nature can very seldom be beaten.

FEEDING METHODS FOR BASS AT FAIRPORT, IA., STATION

By Leslie H. Bennett, Foreman in Charge.

THE CRYING need at all fish hatcheries seems to be plenty of first class food for the fish at the lowest possible cost. At this station, which is pond cultural, we recognize the fact that bass, crappie and bream prefer live food if they can get it. We had found a source of supply of the blackhead, bluntnose, and golden shiner minnows for the brood stock, so that problem was solved, but for the young bass, bream and crappie, it was another question.

We had watched experiments in aquiculture for some time, through the process of fertilizing with shrimp meal, sheep manure, super phosphate and soy bean meal, and knew that this process did increase aquatic life, but as to its abundance we were always kept in the dark, and further felt that these fertilizers were too expensive for our limited finances. As a result of a suggestion from the Chief of the Division of Fish Culture, we tried experiments with cow manure, and there we had a cheap and abundant source of food supply. Now there is cow manure and cow manure, and what we have found out is that manure taken direct from the dairy barn floors is very superior to that obtained in piles for this purpose, therefore we negotiated with a local dairy and obtained fresh droppings for our work. It is possible to purchase this for about $1.50 per ton.

We have ten concrete ponds 46' x 8' x 1'6" in dimension, and we made some crates 6' x 3'30" x 20" and set two of these, in each concrete pond, filled them with good fresh manure, turned the water on and let them fill up, turned the water off when full, and let them stand with the water temperature at 87 degrees or better. Inside of 36 hours the aquatic animal life began to appear, and we have found that they multiply by the millions, and are mostly the common daphnia, but there are also mosquito larvae, red wigglers and other life. We start this process the last of May.

The next step was to get this life out to the nursery pond, so we rigged up a stock tank on a truck and with an electric pump, we pump the bugs into the tank, haul them to our nursery ponds, and do the young bass go after them! After a few trips, the young bass and bream will follow the truck around the pond.

We pro-rate our bass fry at 15,000 to the acre, and for several seasons now, the results in numbers and size have been very gratifying. In one instance this season, we put 16,000 bass fry into one pond on May 28th, fed them steadily, and on October 10th we drained the pond and got out 13,567 #4½ fingerling bass. Of course this was one of our best ponds, and all of them do not produce such a high percentage, but if we did not average over a 40% "take" from our ponds, which we have done consistently of late years, we would be greatly disappointed.

It is noted that some pond culturist has said that after bass get past three inches they will not take small aquatic animal life, but we found that they fed on it just as eagerly in October as in June, and a great many thousands are four, five and six inches in length.

To insure an abundance of food, we place crates in the nursery ponds of the same dimensions as those placed in the concrete ponds, fill them full of manure, and let the sun, wind and water do the rest, and we observe that the bass and bream use these as feeding places, when not fed from the truck. I might add that we change the manure every fourteen days, and it takes about forty tons of manure to keep us going all season on an acreage of a little better than twenty acres of water. The crates placed in the nursery ponds are at the rate of four crates for each acre of water.

Blackhead and bluntnose adult minnows are used in our nursery ponds, and allowed to spawn there, with the result the young fish get considerable food from the young of these forage fish. We also feed maggots to some extent. Beef offals are obtained from the local packing plant at no cost and placed in barrels in the sun, and the maggots resulting make a good food for the bass and bream.

While it is true that the trout culturist has for a number of years recognized the importance of a steady feeding program, it is only in recent years that the pond culturist has taken this matter seriously enough. In view of the increased production since the adoption of this simple but methodical feeding program, we at this station feel that this is the most satisfactory method for our particular circumstances that we have yet discovered.

FEEDING MONTANA GRAYLING FRY

By Harlan E. Johnson, Spearfish, South Dakota

ACCORDING TO published reports on the subject, attempts to feed grayling fry artificially have in many cases met with little success. Therefore the excellent results of an experiment conducted at the Spearfish, South Dakota, hatchery during the summer of 1936, may be of interest to fish culturists.

A shipment of 100,000 Montana grayling (Thymallus montanus) eggs from Yellowstone Park was received at this station on June 13. The eggs hatched on June 24 and 90,000 fry were immediately planted in South Dakota and Wyoming waters. The 10,000 remaining were placed in a trough in the auxiliary hatchery which receives its water supply from an artesian well, the water having a temperature of 51° F. Feeding was begun the day after hatching was completed, but as the fish were so very small it was impossible to see whether or not they began to take the feed immediately. Nevertheless, feeding was continued and the fish were first observed eating small particles of meat on the fifth day after hatching. They rapidly became more voracious and soon were no more difficult to feed than trout of the same age.

The first feed used was beef hearts ground twenty times through a plate having 1/64 inch holes, and was fed to the fish at hourly intervals by shaking it through a small, fine-mesh tea strainer so that all the particles were separated. The yolks of hard boiled eggs were also fed in the same manner for a short time, but as the fish could not be seen eating any of the yolk they were returned to the 100% beef heart diet. For some time it was necessary to place considerably more feed in the trough than the fish would eat, as they did not seem to pick up any of the food after it settled to the bottom. By the first of September the number of times the feed was ground had been reduced to five, and 50 - 75% beef liver was added to the diet. After the second month the number of feedings was reduced to six, and later four, per day. When the grayling were three months old they were transferred to a gravel bottom pond where they continued to grow rapidly until the water temperature dropped below 40° F. late in the fall.

Grayling fry are so much smaller than trout that it is difficult to compare the growth of the two, but it seemed that the experimental lot of grayling, after the first month, grew as fast, or ever faster than trout under the same conditions. At the end of the second month they averaged about one inch in length, were well shaped and very active. By the middle of November, when the water became colder, they had grown to nearly two and one half inches.

Up to January, 1937, there has been a loss of 4,462 in the experimental lot, 1,000 of which was due to escapage when the screen plugged up and the trough overflowed. At no time were there any noticeable indications of disease, the loss being confined to the smaller and weaker individuals. Undoubtedly many of the fry refused to eat the meat and eventually starved as the artesian well water contained little if any natural feed. Very few dead fish were found after the grayling were placed in the gravel bottom pond, though there was probably some loss due to natural enemies. 450 two inch fish were planted in a virgin lake in the Big Horn Mountains of Wyoming.

It is my belief that success in the feeding of grayling fry depends on the following points: Feeding should begin at once after the fry have hatched; the feed should be ground twenty times through a 1/64 inch plate for four or five weeks; the fry should be fed at very frequent intervals, eight times daily for the first month; and the diet should be 100% beef hearts for at least two months.

COMMENTS FROM OUR READERS

FISH CULTURAL PROBLEMS DISCUSSED

Editor, THE PROGRESSIVE FISH CULTURIST:

I wish to express my sincere thanks for your publication. It has given me, and the many thousands of other "amateur" fish culturists, a better understanding of the problems of the scientists who are devoting their lives to this good work. It is the human touch needed to bring to life the cold factual data of scientific publications. My training has been personal y gained while roaming from Panama to Alaska and later through personal experimentation, being a fool who wants to see for himself. And I have proved to my own satisfaction that fish culture can return the average farmer as much per acre of suitable pond surface, as any crop he can grow.

May I state what seems to me to be 3 problems that in future must be keyed into efficient fish culture, to make all capable waters yield a supply of game food fish adequate to ever increasing lists of anglers. Increasing publicity about fishing is resulting in selling the sport to additional thousands of anglers each year. Most states have about reached the carrying capacities of their waters, although in the southern states, where the spiney fins make their best growth, carrying capacities can be doubled.

1. Thousands of pages have been written about hatchery problems, pond rearing of fingerlings, methods of release, control of predators, etc. to one page on improving food conditions, and stocking ponds and streams with various fish goods. We have thousands of acres of good water that can carry but a limited number of fish because the food supply is limited. It is obvious waste to turn cattle on barren pasture, and just as obvious a waste of time and money to release fish in waters barren of sufficient food supply. Why so much (apparently) scientific prejudice against introducing say, shrimp and various types of crustacea, snails, etc., in order to build up a food supply before introducing larger plantings of fish? Is it not entirely feasible to say the fish are not there (water analysis and temperature being suitable) because the food is not there?

2. There is at present a prejudicial overemphasis on such cannabalistic types of game fish as the black bass, wall-eye, musky, pickerel, etc. I make this statement without any personal prejudice on species, knowing it will not meet popular approval. But I have taken a half pound blue bream, followed by a two pound bass, on the same light fly rod and the same fly - and found the bream just as game as the bass! -- and better eating! From personal experience (in North Carolina) I have found that I can grow one bass....But the spectacular strike of the bass at most any kind of lure makes it hard to frown on him as a sporting fish. The same is true of the pikes. Also fishermen want "the biggest fish", and the big-mouthed gluttinous cannibals grow to large size. Perhaps I had better state, in self protection,

that I have caught about every species of fresh water fish that can be taken on hook and line on this continent.

The angler's point of view largely controls the activities of the fish culturist, and the angler pays in the long run to maintain his point of view, often contrary to the good advice of the fish culturist. In future years the angler's point of view is going to need some guidance in the way of discreet propaganda on the sportiness of light tackle and its effective use on the spiney fins such as bream, crappie, calico bass, etc. The majority of anglers today think the fly-rod and flies are useful only on trout. Pound for pound I have found blue bream on a light fly-rod just as game and hard to land as brown trout! - try it before you laugh at me. The trouble is the bream does not grow as large as the brown trout. But we have a thousand acres of water suitable to cultivation of the bream to every acre suitable for brown trout.

If diamonds were as plentiful as the grains of sand, they would not be worth a whoop in hades except for making better mortar and concrete - lasting longer.....The sportsman never values very highly any species of fish that are plentiful. One winter I took a few salt water mullet on a fly-rod, finding them about the fastest, mumpinest, and gamest fish I had ever hooked for their poundage. The memory of those fighting mullet far eclipses the memory of the greyling.....Mullet from Virginia to Panama may be likened almost to the grains of sand, they crowd into the brackish inland sloughs. But maybe a series of articles in sporting magazines would be necessary before the average sport angler would ever think of fishing for them; although he cusses their agility and flashing passage when he tries to catch a few in a seine for bait.

3. More fishermen and scientists are needed in state fish and game departments to replace politicians. Every state should have accurate surveys made of the carrying capacities of its waters, the current stock, and the annual take of fish that can be maintained on a sustained yield basis. A food supply survey is vital, because in practically all cases an increase in fish-food supply means an increase in fish. Thousands of miles of southern mountain streams, which have no fish today, are capable of supporting brown trout. This fish has proven the salvation of many a trout stream in the northern states and mid-west yet there is a prejudice against it here in the south, and thousands of dollars are annually wasted in stocking hatchery brook trout.

From the standpoint of a trout fisherman, I want to bring up this point. The plea of state officials that they have to plant trout that can be caught by the general fishing public, in order to make a showing for their Departments, can easily be understood from the job-holder's angle. But please give the regular trout fisherman a word: Who is this fisherman, or who are those fishermen, preferring to fish over a stretch of water and creeling half a dozen six inch brook trout, rather than have the privilege of fishing over the same water containing 2-4 pound brown trout, whether they have the skill to raise and land one or not?

W. T. Combs,
Conservation Engineer.

USEFUL GLOVES FOR THE HATCHERYMAN

Editor, THE PROGRESSIVE FISH CULTURIST
Washington, D. C.

Dear Sir:

I have a little thing that I believe is worth passing on. Some of the hatchery men may know about it now, but there are many who most likely do not. There is a glove on the market that just fits a long felt need about a hatchery. It is a rubberized canvas glove. They are simply the ordinary heavy canvas ones that have been rubberized. They are water proof and will outwear two or three pairs of the unrubberized ones. They cost only a few cents more and are well worth it. They are just the thing to handle feed, to clean tanks, or to work in the snow.

Ralph H. Olson
Klamath State Hatchery
Klamath Agency, Oregon

NOTES AND NEWS

INTRODUCTION OF THE BROWN TROUT

From Rod and Gun Column by Cecil Heacox, Ithaca Journal, May 1, 1937

AS THE RING-NECK pheasant native of the Orient, has replaced our native game bird, the ruffed grouse, in many sections of this country's upland gunning areas, so the brown trout (Salmo fario) is also a foreign species whose introduction into the United States has been so successful that it has virtually taken over the place held by that most beautiful of fish, our native brook trout.

Since dry fly fishing has advanced so much in recent years and the fact that the brown trout rises so readily to the fly, it is natural that their popularity should go hand in hand. New York State, alone, plants more than two million brown trout of various sizes in its streams each year or more than all other species of trout combined.

In the early part of 1883, a German fish culturist by the name of Von Behr, president of the Deutsche Erei Verein, sent the first brown trout eggs to the United States. They were consigned to the U. S. Fish Hatchery at Northville, Mich. The eggs were incubated and the fry planted in the Pere Marquette River and other streams of Northern Michigan.

Later in the same year, Von Behr sent another shipment to Northville and one to the New York State Hatchery at Caledonia. Thus, the adult fish came to be known as German Brown trout or as the Von Behr trout.

In 1885, England sent to this country eggs of the Loch Leven trout, a closely related species. These eggs went first to the Cold Spring Harbor Hatchery on Long Island where they were repacked and sent to Iowa, Minn., and a private angling club in Herkimer Country.

It was also in 1885 that Von Behr sent eggs of Salmo fario, known on the Continent as Salmo trutta in those days, to the Corry, Pa., Hatchery.

Although the brown trout is not able to withstand the high stream temperatures of which the rainbow is capable, still it can thrive and propagate in waters which are no longer suitable for the more brilliantly colored brook trout.

Summer stream temperatures between 70 degrees and 80 degrees F, will be favorable for brown trout providing the oxygen content approximates three cubic centimeters per liter and there is not undue pollution. As in the case of the other species of trouts, the carbon dioxide content should not exceed five cubic centimeters per liter.

We are accustomed to thinking of our brook, brown and rainbow trouts as stream fish, but they are often found in ponds and lakes. In fact, artificial stocking in our lakes seems to have been uniformly more successful than in our streams. The success of the Tuxedo Club with the so-called steelhead in its Tuxedo Lake and the successful stocking of China Lake by the Carmel Country Club come to mind.

Even more spectacular have been the experiments of the Southern New York Fish and Game Association with brown trout in the waters of the Kensico Reservoir, near White Plains. Since stocking operations began several years ago, good-sized browns have frequently been the reward of the skilled angler, but last year topped the most enthusiastic member's wildest hopes as nearly 100 brown trout over five pounds in weight were taken from the Kensico waters.

The brown trout grows much more rapidly and attains much greater weights than the native brook trout. The largest brown trout on record taken with rod and line weighed 28½ pounds.

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